MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

ENT4086 – DIAGNOSTIC TECHNOLOGY

(NE)

23 OCTOBER 2017
09:00 a.m. - 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

QUESTION 1

(a) (i) With the aid of suitable diagram, explain how could the elemental composition (identity and concentration) detections be possible based on the ion scattering from a sample surface.

[3+4 marks]

(ii) Distinguish the operating principles of ion scattering spectroscopy (ISS) and Rutherford backscattering spectroscopy (RBS) in the contexts of *primary ions energy* and *surface sensitivity*, respectively.

[2+3 marks]

(b) (i) Describe the working principles of Raman spectroscopy (RS).

[4 marks]

(ii) With the aid of energy level diagrams, describe the *Stokes* and *Anti-Stokes* Raman scattering.

[3+4 marks]

(iii) Discuss briefly the gross selection rule for a *Raman active* molecular vibration.

[2 marks]

QUESTION 2

(a) (i) Describe the trade-off relationship between *resolution* and *signal-to-noise ratio* (SNR) in scanning electron microscopy (SEM) imaging.

[3 marks]

(ii) Suggest the type of electron gun that would give SEM images with better resolution and SNR. Justify your answer.

[1+2 marks]

(iii) Suggest **TWO** ways that can be adopted to eliminate or minimize the surface charging effect for non-conductive sample during sample preparation or during the measurement using SEM. Justify your answers.

[2+3 marks]

(b) Suggest the type of operating mode that you should use in magnetic force microscopy (MFM) measurement in order to obtain the magnetic field distributions with the least surface topographic features on the image. Justify your suggestion.

[1+4 marks]

(c) Identify the elements that cannot be determined by the following tools, respectively. Justify your answer for each of the tools:

- X-ray fluorescence (XRF)
- Auger electron spectroscopy (AES)
- Rutherford backscattering spectroscopy (ISS)

[9 marks]

Continued...

QUESTION 3

(a) **Figure Q3(a)** shows the x-ray diffraction (XRD) patterns for three different samples; graphene nanosheets, zinc oxide (ZnO) nanocrystals and ZnO/graphene composite. The XRD measurements were carried out using Cu Kα radiation of 1.5405 Å, and data were recorded in the 2θ range of 20° to 80° with a 10° step size. Answer the following:

(i) Analyse the diffraction patterns in the contexts of *peaks observed* and *crystallinity* of the samples, respectively.

[6+2 marks]

(ii) Given that the full width at half maximum (FHWM) of the (101) peak is 0.8584°, determine the average crystallite size of the ZnO/graphene composite using the Debye Scherrer's equation.

[2 marks]

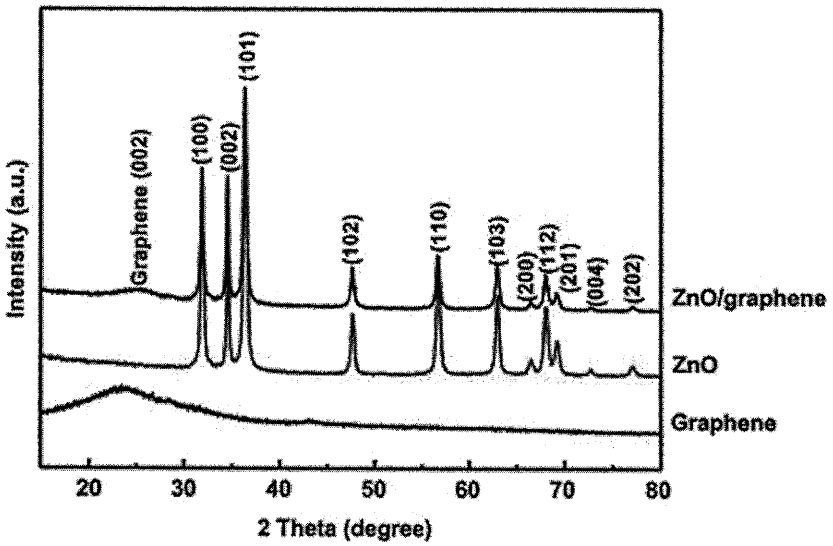

Figure Q3(a)
(Courtesy of H. P. Li et al., 2016)

(b) **Figure Q3(b)** shows the secondary ion mass spectroscopy (SIMS) depth profile of a platinum/hafnium oxide/copper (Pt/HfO/Cu) resistive memory device structure. The Cu layer was synthesized via electrochemical deposition, HfO layer via atomic layer deposition at 250° C, and Pt layer via electron beam evaporation. Answer the following:

(i) Analyse the depth profile spectra in the contexts of *elemental composition* and *thickness* of each layer, respectively.

[3+3 marks]

Continued...

(ii) Based on the spectra, discuss briefly the origin of the presence of a substantial amount of Cu in the HfO layer.

[2 marks]

(iii) Discuss briefly any **TWO** possible ion bombardment effects that lead to the degradation of the depth resolution in the spectra.

[5 marks]

(iv) Suggest possible approach to minimise each of the effect mentioned in **Q3(b)(iii)**.

[2 marks]

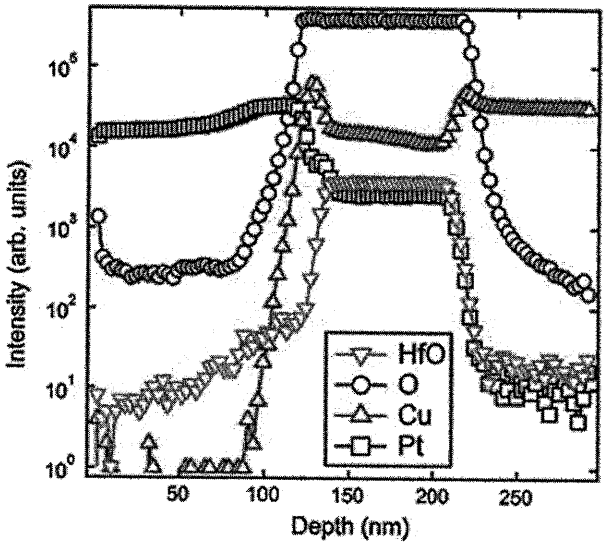

Figure Q3(b)
(Courtesy of B. D. Briggs et al., 2014)

QUESTION 4

(a) **Figure Q4(a)(i)** and **Figure Q4(a)(ii)** show the bright-field (BF) and dark-field (DF) transmission electron microscopy (TEM) images, respectively, of sample consist of nanowires, respectively. Answer the following:

(i) How the bright-field (BF) and dark-field (DF) images are being formed, respectively?

[2 marks]

(ii) Describe any **THREE** conditions for which the electron beam will be transmitted through the samples instead of being scattered or diffracted.

[3 marks]

(iii) Evaluate the surface morphology of the nanowires in the contexts of *length* and *diameter*, respectively.

[2 marks]

(iv) With clear justifications, comment on the degree of crystallinity of the nanowires based on the DF image.

[3 marks]

Continued...

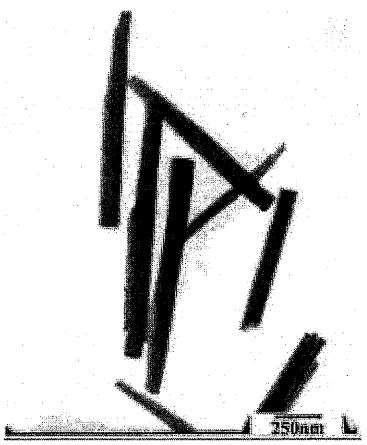

Figure Q4(a)(i)

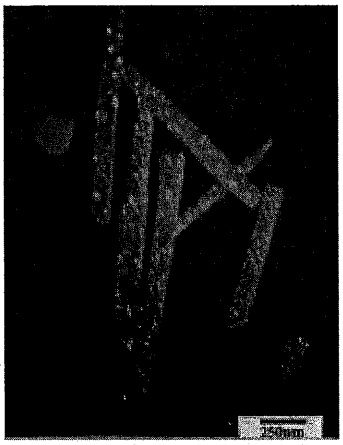

Figure Q4(a)(ii)

(Courtesy of Y. K. Zhou et al., 2002)

(b) **Figure Q4(b)(i)** and **Figure Q4(b)(ii)** shows the Rutherford backscattering spectroscopy (RBS) spectra of molybdenum (Mo)-doped diamond-like carbon (DLC) film deposited on silicon (Si) wafer substrate synthesized using filtered metaled cathodic arc vacuum discharge technique at different substrate biases. Answer the following:

(i) Analyse briefly both spectra in the contexts of *peaks observed* and *metal concentration* in the deposited films, respectively.

[4+2 marks]

(ii) Which spectrum, **Figure Q4(b)(i)** or **Figure Q4(b)(ii)**, shows higher deposited film thickness? Justify your answer.

[1+3 marks]

(iii) How the deposited film thickness can be determined based on the RBS spectrum? Support your answer with a suitable equation.

[2 marks]

(iv) A clear slope at low energy edge of the Mo peaks that can be observed in both spectra are due to energy straggling. Discuss briefly the energy straggling phenomenon.

[3 marks]

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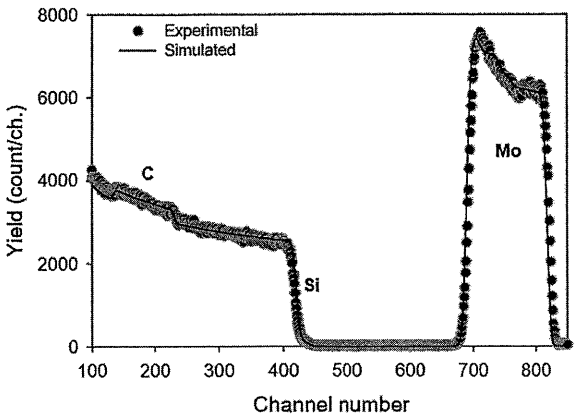

Figure Q4(b)(i)

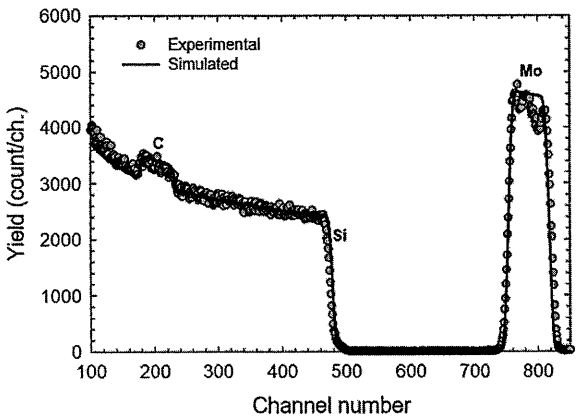

Figure Q4(b)(ii)

(Courtesy of R. K. Y. Fu et al., 2005)

End of Paper